

# NITROGEN MINERALIZATION RESPONSE TO TILLAGE PRACTICES ON LOW AND HIGH NITROGEN SOILS

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## ABSTRACT

In strip tillage, crop residue is left on soil surface, decreasing the contact between soil and the residue, and therefore reducing decomposition rates compared to conventional tillage methods. Decomposition rates directly affect carbon and nitrogen ratios, which can affect nitrogen mineralization rates. The objective of this research is to determine the effect of tillage method and nitrogen rate on nitrogen available to sugar beets planted after a cereal crop. This two-year field study conducted in Kimberly, Idaho, consisted of three tillage methods (moldboard plow, chisel plow, and strip tillage), two tillage timings (fall and spring), and four fertilizer N rates plus a control. Soils from each plot were sampled shortly after nitrogen fertilization and incubated at average seasonal temperatures for Kimberly, Idaho to monitor nitrogen mineralization patterns. In 2008, we found that at N fertilizer rates of 0, 50, and 100 lbs N/acre, intensive tillage (moldboard plow and chisel plow) in the spring had the greatest potential for decreasing plant available nitrogen and increasing soil carbon, while intensive tillage in the fall slightly increased plant available nitrogen. No tillage method or tillage timing effects were detected in 2009, likely due to unexpectedly high residual nitrogen concentrations in the soil. It appears that tillage method and timing are more likely to impact nitrogen mineralization in growth limiting (low N) environments.

## INTRODUCTION

With the introduction of Roundup Ready® sugar beets in 2008, sugar beet growers in Idaho became interested in utilizing strip-tillage to potentially increase economic returns. The advantages associated with strip tillage over conventional tillage in sugar beet production are reduced soil compaction, soil erosion, weed pressure, and labor costs, while increasing total yields, sugar content, soil carbon concentrations, and overall soil quality. Growers are concerned that changing tillage practices will alter nitrogen mineralization dynamics in the soil. Sugar beets have very specific nitrogen needs, producing low yields if the overall available nitrogen is too low, and producing low sugar yields if the nitrate concentrations are too high late in the season. Tillage practices have the potential to impact residue decomposition. Conventional moldboard plowing increases the constant exposure of the residue to air, moisture, soil, and soil microbes, which could hasten the conversion of organic carbon to carbon dioxide. In strip tillage, crop residue is left on soil surface, decreasing the contact between soil and the residue, and therefore reducing decomposition rates compared to conventional tillage methods. Decomposition rates directly affect carbon and nitrogen ratios, which can affect nitrogen mineralization rates. Understanding the effect that tillage operations have on N mineralization will allow growers to develop efficient nutrient management plans specific to tillage operations.

The objective of this research is to determine the effect of tillage method and nitrogen rate on nitrogen available to sugar beets planted after a cereal crop.

## METHODS

The study was performed in collaboration with a field study conducted by David Tarkalson and David Bjorneberg at the USDA-ARS station in Kimberly, Idaho. The experimental design of the field study consisted of three tillage methods (moldboard plow, chisel plow, and strip tillage), two tillage timings (fall and spring), and four fertilizer N rates plus a control. Fifteen soil samples from each plot were extracted from a depth of 12 inches one week after the only application of nitrogen fertilizer (urea) and composited. Soils from each plot were incubated at temperatures adjusted weekly to match the most recent four-year average temperature at an 8 inch soil depth for the ARS station in Kimberly. Samples were analyzed every three weeks for nitrate and ammonium concentrations to estimate nitrogen mineralization and immobilization in the soil. Soils were also analyzed for total carbon and nitrogen content through combustion. Plant available nitrogen in the soil was estimated by summing nitrate and ammonium concentrations at the conclusion of a 4-month incubation period in each of the soil bags (Table 1).

## RESULTS AND DISCUSSION

In 2008, tillage timing (fall vs. spring) had no significant effect on plant available N accumulation over a growing season for strip-till and chisel plowed soils, although there was a trend toward less available N at the 50 and 100 lb N/acre rate (Table 1). The expectation is that timing will have minimal effect on N availability under conservation tillage in comparison to moldboard plowing, as the disturbance to the soil at either time is relatively small. Spring moldboard plowing immobilized a significant proportion of added fertilizer N at all N rates (Table 1). The fall moldboard plow treatment also had significantly less carbon content than all of the spring tillage treatments as an apparent result of residue decomposition over the winter. It is likely that the lower carbon content in the fall moldboard plow treatment in comparison to the spring moldboard plow treatment allowed for increased nitrogen mineralization of the organic N from the residue and from soil organic matter.

**Table 1. Plant available nitrogen accumulated in a Portneuf silt loam after 4 months of incubation at temperatures adjusted weekly to reflect soil temperatures over a growing season in Kimberly, Idaho.**

Year	Tillage	Bedding	UAN application rate (lbs N/acre)					
			0	50	100	150	200	
2008	Strip tillage	Fall	79.0 <i>ab</i>	102.7 <i>ab</i>	101.9 <i>bc</i>	154.7	186.3	
		Spring	91.7 <i>a</i>	81.0 <i>b</i>	121.5 <i>ab</i>	179.7	188.8	
	Chisel Plow	Fall	66.2 <i>ab</i>	96.6 <i>ab</i>	156.8 <i>a</i>	143.8	164.7	
		Spring	59.7 <i>b</i>	88.0 <i>ab</i>	115.7 <i>abc</i>	146.2	169.6	
	Moldboard Plow	Fall	77.2 <i>ab</i>	143.5 <i>a</i>	138.8 <i>ab</i>	171.7	214.9	
		Spring	63.1 <i>b</i>	69.4 <i>b</i>	77.3 <i>c</i>	119.2	108.8	
	P>0.05/LSD		26.9	57.4	44.1	NS	NS	
	2009	Strip tillage	Fall	103.7	95.5	126.2	144.3	215.5
			Spring	100.8	127.7	121.8	163.7	190.1
		Chisel Plow	Fall	90.2	102.8	132.7	142.4	184.9
Spring			97.5	111.8	127.4	132.2	166.2	
Moldboard Plow		Fall	106.8	106.4	128.5	137.0	144.0	
		Spring	134.8	101.1	131.1	131.2	200.3	
P>0.05/LSD		NS	NS	NS	NS	NS		

Fall moldboard plowing significantly increased plant available nitrogen concentrations in comparison to spring mold plowing at the 0, 50, and 100 lb N/acre application rates (Table 1). Spring moldboard plowing immobilized a significant proportion of added fertilizer N at all N rates (Table 1). The fall moldboard plow treatment also had significantly less carbon content than all of the spring tillage treatments as an apparent result of residue decomposition over the winter. It is likely that the lower carbon content in the fall moldboard plow treatment in comparison to the spring moldboard plow treatment allowed for increased nitrogen mineralization of the organic N from the residue and from soil organic matter.

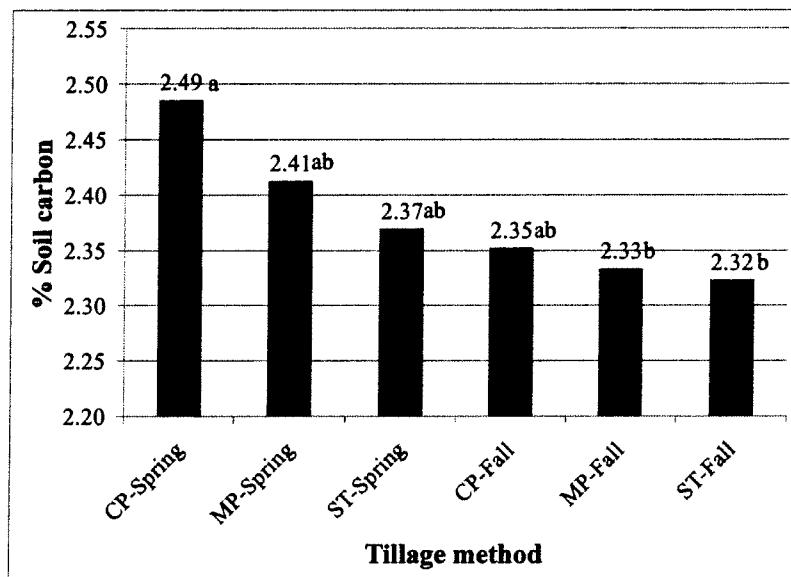
In contrast to 2008, tillage method and tillage timing did not have a significant effect on plant available nitrogen in the soil in 2009 (Table 1). The absence of a tillage effect in 2009 is most likely related to the significant increase in residual nitrogen in the soil in comparison to the 2008 study. From these results it appears that tillage method and timing is more likely to impact nitrogen mineralization in growth limiting environments. More data is needed to explore this possibility further.

While tillage method and timing had no discernible effect on nitrogen mineralization in 2009, the addition of nitrogen rate did significant increase plant available nitrogen at the end of the growing season. This is to be expected, as urea fertilizer is easily converted by microbes to

ammonium and nitrate, therefore increased fertilizer amounts would inherently result in greater concentrations of plant available nitrogen in the soil.

The average carbon content dropped significantly from 2.57 % in 2008 to 2.23 % in 2009, possibly as a result of greater residual nitrogen and moisture in the incubated soil samples. However, an interaction between tillage and year was not detected, indicating that the carbon content trends related to tillage treatments did not change greatly from 2008 to 2009. Also, the application of nitrogen did not affect carbon content in the soil in 2008 or 2009. Added nitrogen can potentially hasten the decomposition of carbon, but this was not apparent for the nitrogen rates used in this study (0-200 lb N/acre).

Because there was not a year by tillage interaction effect or a nitrogen rate effect on soil carbon content, we were able to summarize carbon content based on tillage method (Figure 1). Soils that were chisel plowed in the spring appear to have slightly more carbon than soil strip-tilled or moldboard plowed in the spring and soil chisel plowed in the fall, and significantly more carbon than fall moldboard and strip-tilled soils (Figure 1). As chisel plowing is the partial incorporation of residues into the soil, it would seem plausible that more carbon would build up in comparison to heavily tilled soils that have more aeration and mixing to speed up decomposition of residues, and strip-tilled where incorporation of residues into the soil is minimal. Also, as spring tillage occurs only a few weeks prior to planting, while fall tillage occurs approximately five months, there is more time for residues to decompose for fall tilled soils in comparison to spring tilled. Decomposition may be slowed under cool winter temperatures, but temperatures were apparently not enough to completely prevent decomposition from occurring.



**Figure 1. Effect of tillage treatment and timing for soil carbon content at a one-foot depth for a Portneuf silt loam at planting, averaged over 2008 and 2009 and over nitrogen rates. CP = Chisel plow, ST = Strip-till, MP = Moldboard plow.**